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ABSTRACT

Although sex differences in research have received considerable attention, few researchers have examined the bias, social context, and process of that research. In analyzing sex differences in academic achievement over the past 10 years, three areas (mathematics, spatial ability, and verbal ability) would appear to establish consistent sex differences. However, upon closer examination of spatial ability research, only one distinct area within the construct, mental rotations, shows sex difference. Other areas, such as horizontality/verticality, do not truly measure spatial ability and therefore should not confound the research and results. The hypotheses for sex differences stem from the nature/nurture or biological versus sociocultural explanations. Biological premises, specifically genes, hormones, brain structure and function, and timing of pubertal changes, have been used to support sex differences in spatial ability and mathematics. However, under closer scrutiny only hormones, and then only as they relate to the levels present in the body, have been correlated with sex differences in cognitive performance. Research on socialization suggests that parental expectations, school structure arrangements, and sex role socialization affect academic achievement. Most research on spatial ability suffers from the chicken and egg dilemma, since it cannot be determined which comes first: spatial skill or interest in spatial activities. Until more scientific rigor is required in studies of sex differences, the research being done will only reinforce stereotypic beliefs. (BL)

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The Development of Sex-Related Differences in Achievement

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Invited presentation in a State-of-the-Art symposium on "Sex Differences in Achievement" at the annual meeting of the American Psychological Association in Anaheim, California, August 29, 1983.

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I want to begin by thanking the Program Committee of Division 15 for selecting sex differences as a topic to be highlighted at this convention. This is indeed an important topic--although, as you might expect, my views are biased! External evidence for its importance comes from such purveyors of truth as Psychology Today, in which an article a few years ago declared, "there is no hotter topic in psychology," with reference to cognitive sex differences and the brain (Goleman, 1978). Since the publication in 1974 of Maccoby and Jacklin's volume, The Psychology of Sex Differences, there has been a great deal of research and writing on this topic. Indeed, their review appears to have stimulated sex difference research generally as well as several specific lines of research.

Before reviewing the current status of knowledge on sex differences in achievement, however, it is important to say something about the context and process of doing such research. These factors are important in any area of science, but are especially important for an area in which there are strongly held beliefs. Each of us has beliefs about sex differences. We make attributions about our children, our friends and colleagues, and ourselves, based on beliefs, accurate and inaccurate, about differences between the sexes. Such beliefs have influenced the

way in which research on sex differences has been conducted, from question formulation to sample and method selection to inferences. The result is a set of findings strongly influenced by the various biases that informed the research. One needs then to consider the biases when interpreting the findings.

Another important point to keep in mind when considering sex differences research is that what has been is not necessarily what will be with respect to sex differences. An example from an area other than achievement will clarify my point. When I began my research looking at hormone-behavior relationships about a dozen years ago, it was believed that the musculature of males and females formed nearly mutually exclusive distributions. This belief about musculature fit the data on sex differences in athletic achievements as well as in the distribution of hormones thought to underlie the observed differences in musculature. More recently, these beliefs have been challenged by the evidence provided by an increasingly larger number of women athletes. Although there probably are some limits to the muscle development of women that would, even with equal exercise, produce sex differences in the distribution of musculature, these differences are much smaller than we believed previously. Photographs of the legs of male and female runners, for example, demonstrate that it is virtually impossible to identify sex on the basis of leg muscle development. We now see that social conventions about the

inappropriateness of exercise for women had limited the kinds of bodies that we were able to observe.

In the area of academic achievement, we have seen similar though less dramatic changes over the last decade or so. Women now constitute 49.7% of all baccalaureate recipients (Trent, 1983). Women are visible in professions, such as business, law, and medicine, where their presence was very unusual in the past. Even a field such as engineering, thought to require skills typical of males, has seen a fourfold increase in the number of women--although the percent of women now obtaining baccalaureate degrees in engineering is still only about 4%.

In my presentation, I will review the state of current knowledge of sex differences in cognitive achievement and the development of these sex differences. I will return later to the issue of the social context, particularly in terms of the biases that have led us to ask only certain questions and therefore neglect a large set of important topics. These observations will form the basis for some recommendations for areas needing investigation.

The Status of Research on Sex Differences

Maccoby and Jacklin (1974) suggested that there were four areas in which consistent sex differences were firmly established. Three of these--mathematics, spatial ability, and verbal

ability--are directly relevant to achievement. Maccoby and Jacklin concluded that males on the average obtain higher scores on tests of mathematics and spatial ability and that females typically perform at higher levels on tests of verbal ability.

In a recent review of sex differences research, my co-authors and I concluded that research since the Maccoby and Jacklin volume basically confirms their conclusions (Petersen, Crockett, & Tobin-Richards, 1982). We noted, however, that little additional research has been done on verbal skills--the one area in which females excel. In the areas of mathematics and spatial ability, research has identified those factors--such as subgroups of individuals or specific tests--that moderate the general conclusion about sex differences. Since we have on the panel today, the foremost researcher of sex differences in mathematics--Elizabeth Fennema--and since our other panelist--Camilla Benbow--is a noted researcher of sex differences among the mathematically precocious, I will focus on new findings from the study of spatial ability.

Upon seeing a draft of my review paper mentioned earlier, Marcia Linn suggested that we subject to a meta-analysis the findings from the 172 studies of spatial ability. We presented these results earlier at this meeting (Linn & Petersen, 1983), and I will just briefly summarize them. Using a method of meta-analysis that also tests for homogeneity among the effect

sizes, we found three subtypes of spatial ability. The largest groups of studies--about 75 percent of the total--used measures that required analytic ability for solution. Examples of tests employed by these studies are the Differential Aptitude Test Space Relations Subtest (Figure 1a), the Embedded Figures Test (Figure 1b), and Paper Folding. We called this construct Spatial Visualization. No significant sex effect was found for this construct. The effect sizes averaged one-tenth of a standard deviation.

On two other homogenous constructs, both really only emerging in studies in the past decade, we did find sex differences: Horizontality/Verticality and Mental Rotations. Horizontality/Verticality is measured by the Rod and Frame Test and tests requiring judgment of horizontality of water level (example in Figure 2). The effect sizes averaged about one-third of a standard deviation across age groups with no difference by age. We believe that these tests are solved through kinesthetic processes.

Mental Rotations tests included Vandenberg's Mental Rotations Test (Figure 3a), an adaptation of the Shepherd-Metzler task, as well as the Primary Mental Abilities Space subtest (Figure 3b). The effect sizes here averaged about one-third of a standard deviation. These tests require rapid analog processing for the achievement of high scores.

This meta-analysis addressed some issues of the development of sex differences, a topic I will get to shortly. In terms of the existence of sex differences, however, we concluded that most measures of spatial ability do not show consistent sex differences across studies. These tests typically require analytic skill with spatial visual stimuli, skill that boys and girls appear to have equally. Two distinct areas do show sex differences, only one of which appears to be truly spatial. Tests of horizontality/verticality seem to require kinesthetic sense for solution. Mental rotations, however, are spatial and show sex differences.

A very interesting aspect of research on sex differences is the great investment in finding them. I predict that this motivation will have a measurable effect in the area of spatial ability over the next few years. To many researchers, the major criterion for a good test of spatial ability is that it shows sex differences. This totally confounds the issue. We have already been seeing an increase in studies using measures of the two kinds of spatial ability showing consistent sex differences. Indeed, I recently read a paper (Pearson & Ialongo, 1983) using two of these measures. Stronger sex differences were found in this study than were reported in the two meta-analyses (Hyde, 1981; Plomin & Foch, 1981) of studies reported by Maccoby and Jacklin (1974). The authors of this recent paper, overlooking the possibility that spatial ability is not a single domain, and that the studies

reviewed in Maccoby and Jacklin used a broader set of measures than the ones used in the research presented, took the earlier reviewers to task for minimizing the magnitude of the sex difference. I predict that this sort of research will become more prevalent in the future and that the measures used for spatial ability will be selected only from the constructs showing sex differences. Although much interesting research needs to be done with these constructs, exclusive focus on them will greatly narrow the definition of spatial ability and insure that increasingly larger effect sizes for sex are found. All of those tests which for many years were considered to measure spatial ability will be forgotten or perhaps renamed.

Research on the Development of Sex Differences

Maccoby and Jacklin also reviewed research on the development of sex differences. The hypotheses for development fall basically into two general categories: nature/nurture, biological or sociocultural explanations. As I have noted previously (Petersen, 1980), research on biological influences has been more specifically linked to observed sex differences in the domains in question, while socialization research has not been as specifically focused, focusing less on actual outcomes than on the simple observation of differential socialization. (There are, however, some recent notable examples to the contrary.) Furthermore, there has been much more research on biological than

on social processes affecting sex differences, particularly in the cognitive and achievement domains.

Biological Explanations

Biological explanations have been commonly advanced for sex differences, and this is particularly true with spatial ability and mathematics. Genes, hormones, brain structure and function, and the timing of pubertal changes have all been pursued as biological explanations (Crockett & Petersen, in press; Sherman, 1978). I shall briefly review each of these areas in turn.

Genes. Although no evidence has been found for genetic influence on sex difference in mathematics, there has been substantial research on the possibility of x-linked gene influence with spatial ability. Early indications that there was such an effect (e.g., Bock & Kolakowski, 1973) have now been basically refuted (e.g., Vandenberg & Kuse, 1979), although there still are investigators who believe that with better methods, support for the genetic hypothesis will be attained (Thomas, 1983). Because the inconsistent findings could be due to combining studies using measures that showed sex differences with those that did not in the meta-analysis described earlier, we arrayed the studies by construct measured and then examined the nature of support for the genetic hypothesis. This attempt failed to change the conclusion. Overall, more studies failed to find evidence for x-linkage than

to find such evidence, and there was no effect of construct type (Linn & Petersen, 1983).

Hormones. Earlier research of mine (Petersen, 1976) as well as two recent studies (Berenbaum & Resnick, 1982; Cantoni, 1981) found evidence that androgen levels--the "male" hormone--are related curvilinearly to spatial ability, with intermediate levels (high for females, low for males) associated with higher scores on spatial ability tests. This pattern of hormone influence differs, however, from the linear pattern expected on the basis of the sex differences. It is not more male hormone that might be important but rather a particular level of hormone, probably in combination with other hormones (Petersen, 1979). Whatever hormone effects are established, more research using direct hormone measures is needed in this area.

Brain structure and function. This is the area thought "hottest" in psychology. There is recent evidence of differing structures of male and female brains (e.g., Ayoub, Greenough, & Juraska, 1983; deLacoste-Utamsing & Holloway, 1982), although the areas that differ by sex are typically those related to sexual functioning. There also is some evidence of sex differences in the hemisphere of the brain typically used for processing certain kinds of information (McGlone, 1980; see also the subsequent commentaries). This latter area of research, however, is totally confounded by the nature of the behavioral evidence used to infer

sex differences in laterality. For example, males and females tend to use different strategies with laterality measures (Bryden, 1979). Furthermore, it is not known whether sex differences in laterality are present at birth or develop over time (Petersen, 1982). If the latter proves to be true, these sex differences in brain functioning could also be a result of differential socialization practices.

Timing of puberty. Maccoby and Jacklin (1974) observed that the sex differences in cognition and achievement appeared to first emerge in early adolescence. Their observation led to several studies exploring the impact of pubertal change and its timing on these sex differences (Newcombe & Bandura, 1983; Petersen, 1983; Waber, 1976). In the meta-analysis of spatial ability studies summarized earlier, no evidence was found for emergence during early adolescence of the sex difference in spatial ability (Linn & Petersen, 1983). This finding is consistent with the general lack of results showing effects of pubertal timing on cognitive patterns. With only one cognitive skill does there seem to be some effect of puberty and this is only a temporary one. Susan Carey and her colleagues (Carey, 1981; Carey & Diamond, 1980; Carey, Diamond, & Woods, 1980) have found a dip in the ability to recognize faces during puberty. No sex differences, however, are found with this skill.

Socialization Influences

As noted earlier, most of the earlier research on socialization effects failed to link these processes with specific areas in which there were sex differences. Recent research, however, has addressed these linkages. The research program of Jackie Eccles (Parsons), for example, has demonstrated the potent influences of parental expectations, though not parental modeling, on children's expectancies for achievement in mathematics (Parsons, Adler, & Kaczala, 1982). In fact, parental expectations were stronger than children's prior achievement in producing achievement attitudes and expectancies.

Another new area of research is that focusing on school structure arrangements. In one interesting experiment with grouping of students (Saltzer, 1983), it was found that the mathematic achievement of girls was significantly enhanced when grouping ignored sex but focused only on individual differences.

Sex role socialization has not produced consistent findings in terms of the effects on achievement (Maccoby & Jacklin, 1974). Methodological problems plague this area, but, in addition, the clear sex differences in sex role orientation make it difficult to unconfound sex role orientation from sex role socialization. Bem's (1982, 1983) new focus on gender schema theory promises to revitalize this line of research and begin to shed some light on the social and individual processes involved. In general,

research on sex roles needs to focus more on within-sex than between-sex differences.

With spatial ability, there is evidence that engaging in spatially-oriented tasks, often sex typed as male, is linked with greater spatial skill (Newcombe, Bandura, & Taylor, 1983; Tobin-Richards & Petersen, 1981). We have a chicken and egg problem here, however, since we can't differentiate which comes first: spatial skill or interest in spatial activities. Longitudinal research is needed to unconfound these factors.

Summary and Recommendations

Research on sex differences and their development has been plagued by bias, leading to what has been termed (Linn & Petersen, 1983) a "speculative chain of assumptions." Much of the sex difference research in cognition and achievement, particularly in the past decade, has focused on two constructs: spatial ability and mathematics achievement. Whereas sex difference research prior to the Maccoby and Jacklin volume focused on a somewhat broader range of issues, research in the last decade seems to have been primarily reactionary, focusing solely on the two constructs in which males were thought to have an advantage. Although there are some interesting questions yet to be pursued with these constructs, it is essential that we keep the scientific questions, rather than the political issues, foremost. For example, with spatial ability it now appears that attention is largely focused

on two narrow domains, only one requiring spatial processing: (1) judgment of verticality/horizonality, which appears to require more kinesthetic than spatial judgment and (2) mental rotations, a clearly spatial construct although one involving analog processing. Whether this latter construct has predictive validity in relation to occupational achievement or even educational achievement in specific fields remains to be seen. Clearly, the tests that Linn and Petersen included in the spatial visualization construct--the one without a significant sex difference--have greater face validity for importance and would seem to have more predictive power for a greater variety of outcomes.

Until we have a clearer understanding of which constructs show sex differences, efforts to explain their development are less likely to be productive. Although it is very important to understand brain processing and hormonal influences, for example, we must be aware that these specific processes that may have no generality in terms of a whole array of outcomes to which they are commonly applied, such as pursuit of a career in engineering. A major problem with writing about sex differences has been the looseness and superficiality with which inferences are made across broad domains. For example, research on sex differences in the brain is presented as if it ought to explain any differences in male-female behavior. Scientific understanding in this area will not be advanced unless we begin to clearly specify the scientific

problems--particularly in terms of the processes we purport to examine as well as the methods to address them. Most importantly, the inferences based on findings must be clear about the limits to their generality.

A much larger issue requiring attention is that the domains investigated in sex difference research have been extremely limited. If sex differences are examined so as to enhance our understanding of human functioning, as I believe they ought to be, then we should sample from the broad array of important aspects of human functioning. (Instead, much of the research seems to be providing indicators of gender. We really don't need good measures of sex since there exist several perfectly appropriate, easily administered ones--such as simply asking the individual.) In contrast, the whole area of verbal proficiency, in which females excel, has received much less attention. In addition, we know next to nothing about such potentially important aspects of functioning as intuition, an area frequently identified as one in which women excel. Intuition might be critical for a whole variety of judgments made daily by people, and may be especially important in some fields. And yet there is virtually no scientific investigation of this topic. Some colleagues and I considered pursuing this construct some years ago, but finally concluded that all of us were too junior to risk developing an area without adequate conceptualization and measures.

It is also curious that so little of the sex difference research has been related to the criterion measures purported to provide a rationale for the research. For example, it is common in studies of spatial ability to read that it is a critical aspect of human functioning. Its critical nature, however, has not been demonstrated and seldom even considered except for occasional references to its usefulness for hunters, or for Eskimos needing to differentiate figure from ground while hunting in the snow. Some of the early spatial tests were linked to skill areas but most of these tests now fall in the group showing no sex difference.

I have not drawn a very favorable picture of research on sex differences, a perspective on this area that is certainly not new (cf. Shields, 1975). We must begin to demand more scientific rigor in studies of sex differences, unless, of course, what we really want is to have our beliefs reinforced.

References

Ayoub, D. M., Greenough, W. T., & Juraska, J. M. (1983). Sex differences in dendritic structure in the preoptic area of the juvenile Macaque monkey brain. Science, 219, 197-198.

Bem, S. L. (1982). Gender schema theory and self-schema theory compared: A comment on Markus, Crane, Bernstein, & Siladi's "Self-schemas and gender." Journal of Personality and Social Psychology, 43, 1192-1194.

Bem, S. L. (1983). Gender schema theory and its implications for child development: Raising gender aschematic children in a gender-schematic society. Signs: Journal of Women in Culture and Society, 8, 598-616.

Berenbaum, S. A., & Resnick, S. (1982). Somatic androgyny and cognitive abilities. Developmental Psychology, 18, 418-423.

Bock, R. D., & Kolakowski, D. (1973). Further evidence of sex-linked major gene influence on human spatial visualizing ability. American Journal of Human Genetics, 25, 1-14.

Bryden, M. P. (1979). Evidence for sex-related differences in cerebral organization. In M. A. Wittig & A. C. Petersen (Eds.), Sex-related differences in cognitive functioning: Developmental issues (pp. 121-143). New York: Academic Press.

Cantoni, V. J., Pellegrino, J. W., & Hubert, L. J. (1981). The relationship between testosterone levels and human spatial

abilities. Unpublished manuscript (available from V. Cantoni, School of Education, University of California--Santa Barbara).

Carey, S. E. (1981, September). Maturation and the development of spatial ability in children. Paper presented at a conference "Gender-Role Development: Conceptual and Methodological Issues," National Institutes of Health, Bethesda, MD.

Carey, S. E., & Diamond, R. (1980). Maturational determination of the developmental course of face encoding. In D. Caplan (Ed.), Biological studies of mental processes (pp. 60-93). Cambridge, MA: MIT Press.

Carey, S. E., Diamond, R., & Woods, B. (1980). Development of face recognition--A maturational component? Developmental Psychology, 16, 257-269.

Crockett, L., & Petersen, A. C. (in press). Biology: Its role in gender-related educational experiences. In E. Fennema & J. Ayer (Eds.), Equity or equality: Women and education. Chicago: NSSE and McCutchan.

deLacoste-Utamsing, C., & Holloway, R. L. (1982). Sexual dimorphism in the human corpus callosum. Science, 216, 1431-1432.

Diamond, R., Carey, S., & Back, K. J. (1983). Genetic influences on the development of spatial skills during early adolescence. Cognition, 13, 167-185.

Goleman, D. (1978). Special abilities of the sexes: Do they begin in the brain? Psychology Today, 12, 48-56, 59, 120.

Hyde, J. S. (1981). How large are cognitive gender differences? A meta-analysis using w^2 and d. American Psychologist, 36, 892-901.

Linn, M. C., & Petersen, A. C. (1983). Emergence and characterization of gender differences in spatial ability. Presented at the annual meeting of the American Psychological Association, Anaheim, CA. To be submitted for publication.

Maccoby, E. E., & Jacklin, C. N. (1974). The psychology of sex differences. Stanford, CA: Stanford University Press.

McGlone, J. (1980). Sex differences in human brain asymmetry: A critical survey. The Behavioral and Brain Sciences, 3, 215-227.

Newcombe, N., & Bandura, N. M. (1983). Effect of age at puberty on spatial ability in girls: A question of mechanism. Developmental Psychology, 19, 215-224.

Newcombe, N., Bandura, N. M., & Taylor, D. G. (1983). Sex differences in spatial ability and spatial activities. Sex Roles, in press.

Parsons, J. E., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. Child Development, 53, 310-321.

Pearson, J., & Ialongo, N. (1983, April). Gender, athletic, and academic activity as predictors of spatial ability: Sex role as mediator. Paper presented at the meetings of the Society for Research in Child Development, Detroit.

Petersen, A. C. (1976). Physical androgyny and cognitive functioning in adolescents. Developmental Psychology, 12, 524-533.

Petersen, A. C. (1979). Hormones and cognitive functioning in normal development. In M. A. Wittig & A. C. Petersen (Eds.), Sex-related differences in cognitive functioning: Developmental issues (pp. 189-214). New York: Academic Press.

Petersen, A. C. (1980). Biopsychosocial processes in the development of sex-related differences. In J. Parsons (Ed.), The psychobiology of sex differences and sex roles (pp. 31-55). New York: Hemisphere.

Petersen, A. C. (1982). A biopsychosocial perspective on sex differences in the human brain. The Behavioral and Brain Sciences, 2, 312.

Petersen, A. C. (1983). Pubertal change and cognition. In J. Brooks-Gunn & A. C. Petersen (Eds.), Girls at puberty: Biological and psychosocial perspectives (pp. 179-198). New York: Plenum Press.

Petersen, A. C., Crockett, L., & Tobin-Richards, M. H. (1982). Sex differences. In H. E. Mitzel (Ed.), Encyclopedia of education research (5th ed.). New York: The Free Press.

Plomin, R., & Foch, T. (1981). Sex differences and individual differences. Child Development, 52, 383-385.

Sherman, J. A. (1978). Sex-related cognitive differences: An essay on theory and evidence. Springfield, IL: Charles C. Thomas.

Shields, S. A. (1975). Functionalism, Darwinism, and the psychology of women: A study in social myth. American Psychologist, 30, 737-754.

Thomas, M. (1983). Familial correlational analyses, sex differences, and the x-linked gene hypothesis. Psychological Bulletin, 93, 427-440.

Tobin-Richards, M. H., & Petersen, A. C. (1981, August). Spatial and sex-appropriate activities: Spatial visual ability during adolescence. Paper presented at the meetings of the American Psychological Association, Los Angeles.

Trent, W. T. (1983). Race and sex differences in degree attainment and major field distributions from 1975-76 to 1980-81 (Rep. No. 339). Baltimore, MD: The Johns Hopkins University, Center for Social Organization of Schools.

Vandenberg, S. G., & Kuse, A. R. (1979). Spatial ability: A critical review of the sex-linked major gene hypothesis. In

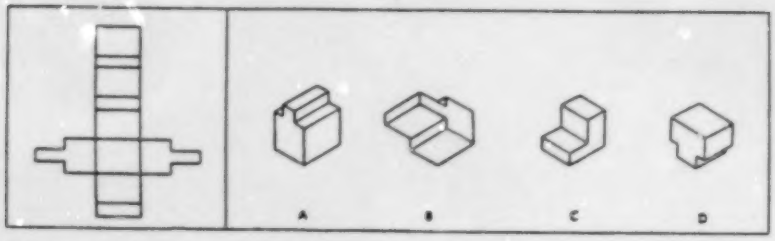
M. A. Wittig & A. C. Petersen (Eds.), Sex-related differences in cognitive functioning: Developmental issues (pp. 67-95). New York: Academic Press.

Waber, D. P. (1976). Sex differences in cognition: A function of maturation rate? Science, 1982, 572-574.

Fig. 1 Spatial Visualization Measures

DAT Space Relations

a.



EFT (Embedded Figures Test)

b.

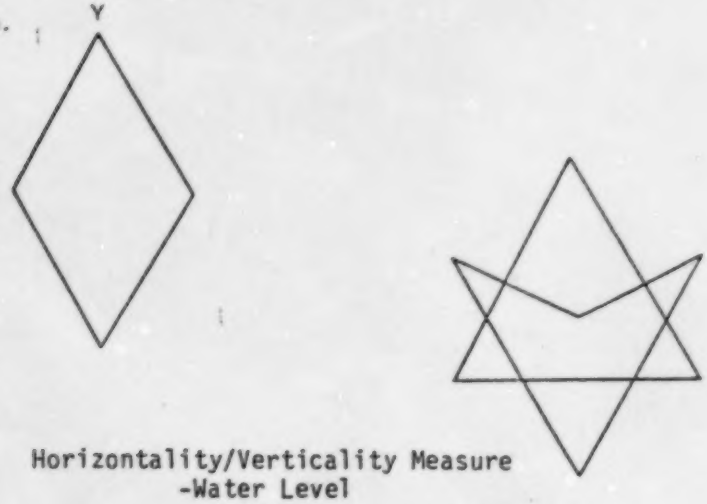


Fig. 2 Horizontality/Verticality Measure
-Water Level

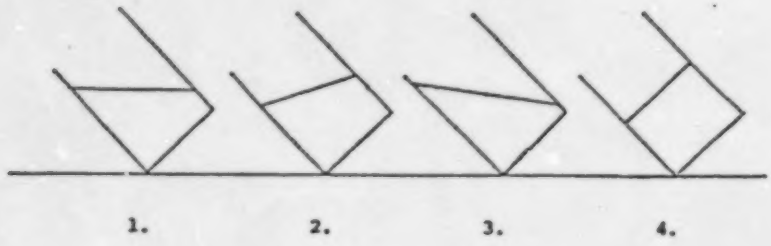
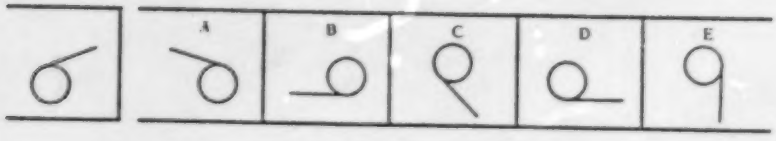


Fig. 3 Mental Rotations

PMA Space

a.



Vandenberg Mental Rotations

b.